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CONTRACTILE FUNCTION OF THE MYOCARDIUM WITH PROLONGED
HYPOKINESIA IN PATIENTS WITH SURGICAL TUBERCULOSIS

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Translation of "Sokratitel'naya funktsiya miokarda pri
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16. Abstract The changes in the myocardial contractile function with hypokinesia in surgical tuberculosis patients is discussed. The phase nature of the changes is noted, specifically the changes in the various systoles, diastole, and other parts of the cardiac cycle. The data compares these changes during confinement in bed with no motor activity to and with a return to motor activity after leaving the in-bed regimen.			
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The disturbances of the functional state of various organs and systems of the human body, which accompany the restriction of muscular activity, have attracted the attention of physiologists and clinical physicians for a long time. The complex of disorders of the vital activity of the body from motor inadequacy is designated as the "hypokinetic syndrome" (A.V. Korobkov, 1961; L. I. Kakurin, 1968; Kraus, Raab, 1961, and others).

/8*

The effect of a lack of muscular activity on the healthy body has been studied quite completely (A.V. Korobkov, 1961; V.S. Georgievskiy, V.M. Mikhailov, 1968; L.I. Kakurin, 1968; L.A. Ioffe, 1971, and others). The pathology of the body, associated with prolonged confinement to bed with some diseases, has been studied less.

Studied in the present work is the contractile function of the myocardium of the left ventricle with prolonged confinement to bed in patients with surgical tuberculosis. 119 patients and 20 healthy persons, from 18 to 60 years of age, were examined. 69 of the patients, suffering from different forms of surgical tuberculosis, followed an in-bed regimen for from 3 months to 1.5 years (first group). 50 patients used a free regimen (second group). The contractile function of the myocardium was studied according to the data of phase analysis of the cardiac cycle of the left ventricle,

/9

/10

*Numbers in the margin indicate pagination in the foreign text.

TABLE
PHASE STRUCTURE OF SYSTOLE OF LEFT VENTRICLE IN PATIENTS
WITH SURGICAL TUBERCULOSIS, AS A FUNCTION OF THE NATURE
OF THE REGIMEN ($M \pm m$, IN SECONDS)

Этапы жизни лица	a	b	c	d	e	f	g	h	i	j
		Сердечный цикл	Фаза систо- лического со- кращения	Фаза изомет- рического со- кращения	Период на- пряжения	Период релак- сации	Митральная систола	Общая систола	Диастолическая систола	Диастола
1	2	3	4	5	6	7	8	9	10	11
к Период постельного режима	Исходный период	0,750* ± 0,013	0,063* ± 0,002	0,031* ± 0,002	0,094 ± 0,003	0,242* ± 0,002	0,273* ± 0,003	0,338* ± 0,003	0,351 ± 0,002	0,433* ± 0,011
	m									
	1 месяц	0,707* ± 0,010	0,066* ± 0,001	0,035* ± 0,001	0,095 ± 0,002	0,242* ± 0,002	0,273* ± 0,003	0,337* ± 0,003	0,355 ± 0,001	0,422* ± 0,011
	n									
	3 месяца	0,759* ± 0,029	0,062* ± 0,002	0,030* ± 0,002	0,092 ± 0,003	0,242* ± 0,002	0,272* ± 0,003	0,336* ± 0,003	0,368 ± 0,004	0,427* ± 0,013
	o									
	6 месяцев	0,718* ± 0,023	0,061 ± 0,001	0,037 ± 0,002	0,098 ± 0,002	0,227* ± 0,006	0,267* ± 0,006	0,322* ± 0,007	0,354 ± 0,005	0,422* ± 0,021
	p									
	1-1,5 года	0,724 ± 0,026	0,061 ± 0,001	0,045 ± 0,006	0,101* ± 0,006	0,233* ± 0,010	0,277* ± 0,012	0,338 ± 0,008	0,345 ± 0,011	0,428* ± 0,015
д Период после выхода больных	Исходн. пе- риод перед вылеч.	0,752* ± 0,017	0,059* ± 0,001	0,038 ± 0,002	0,097 ± 0,002	0,235* ± 0,004	0,272* ± 0,004	0,330* ± 0,005	0,340* ± 0,005	0,425* ± 0,013
	s									
	1 неделя	0,756* ± 0,015	0,067* ± 0,001	0,035* ± 0,002	0,102* ± 0,002	0,243* ± 0,003	0,278 ± 0,001	0,344 ± 0,003	0,355 ± 0,005	0,412* ± 0,010
	t									
	3-4 месяца	0,763* ± 0,032	0,062* ± 0,004	0,037 ± 0,004	0,099 ± 0,002	0,241* ± 0,007	0,278* ± 0,005	0,340 ± 0,006	0,350 ± 0,003	0,422* ± 0,027
и Свободный режим	Исходн. пе- риод	0,777* ± 0,014	0,058* ± 0,002	0,036 ± 0,002	0,094 ± 0,002	0,238* ± 0,003	0,273* ± 0,003	0,334* ± 0,004	0,359 ± 0,003	0,463* ± 0,012
	m									
	1 месяц	0,808 ± 0,022	0,054 ± 0,002	0,038 ± 0,002	0,093 ± 0,003	0,259 ± 0,004	0,298 ± 0,004	0,351 ± 0,002	0,357 ± 0,004	0,476 ± 0,021
	v									
	3-6 меся- цев	0,823 ± 0,020	0,052 ± 0,007	0,039 ± 0,004	0,091 ± 0,006	0,249 ± 0,008	0,288 ± 0,009	0,346 ± 0,008	0,349 ± 0,007	0,457 ± 0,023
w Здоровые лица		0,862 ± 0,019	0,018 ± 0,002	0,040 ± 0,003	0,088 ± 0,005	0,268 ± 0,005	0,308 ± 0,006	0,357 ± 0,007	0,358 ± 0,004	0,506 ± 0,018

*The result is statistically reliably different from that in the group of healthy patients.

NOTE: Commas in tabulated material are equivalent to decimal points.

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KEY:	a. Stages of observation	l. Initial period
	b. Cardiac cycle	m. 1 month
	c. Phase of asynchronous contraction	n. 3 months
	d. Phase of isometric contraction	o. 6 months
	e. Period of tension	p. 1-1.5 years
	f. Period of expulsion	q. Period after leaving bed
	g. Mechanical systole	r. Initial period before leaving bed
	h. General systole	s. 1 week
	i. Electrical systole	t. 3-4 months
	j. Diastole	u. Free regimen
	k. Period of confinement to bed	v. 3-6 months
		w. Healthy persons

using Plumberger's method (1940) with the computing of the complex indicators and the detection of the phase syndromes proposed by V. L. Karpman (1965). The rate of emptying of the left ventricle and the outlay of cardiac energy for the movement of 1 liter of blood were calculated with regard for the instantaneous volume of blood, determined according to the formula of M. N. Syvorotkin (1967). The material was processed by the method of variational statistics, with regard for the criteria of reliability of the differences, according to Student.

The initial background of the phase structure of the systole of the left ventricle in patients with surgical tuberculosis differed considerably from that in healthy persons. As is evident from the table, upon admission to the hospital, a reliable decrease in the duration of the cardiac cycle was noted in the patients, because of the shortening of the mechanical and general systoles, as well as the diastole period. The length of the phase of isometric contraction and the period of expulsion decreased at the same time. The phase of asynchronous contraction lengthened reliably. The functional deficiency of the contractile myocardium was also characterized by low values of Blumberger's mechanical coefficient (2.57 ± 0.08 , as opposed

to 3.04 ± 0.20 in the healthy persons, $P < 0.05$) and a high index of myocardial tension ($27.76 \pm 0.76\%$, as opposed to $24.65 \pm 1.03\%$, $P < 0.05$) in the initial period. With increased energy outlay for the expulsion of 1 liter of blood (13.40 ± 0.65 watts/minute, as opposed to 10.77 ± 0.38 watts/minute, $P < 0.05$), the power of the left ventricle in patients in the initial period was considerably lower than in the healthy persons (3.29 ± 0.29 watts, as opposed to 4.12 ± 0.29 watts, $P < 0.05$). All of these cardiachronometric disturbances and changes on the part of the complex indicators of the phase structure of the systole indicate a weakening of the contractile function of the myocardium of the left ventricle in patients with surgical tuberculosis, which is furthered by specific intoxication, the presence in a number of patients of purulent sites in the body (tuberculous abscesses), and the presence in some of the patients of pathology of the nervous system with spinal disorders.

The initial indicators of the phases of the cardiac cycle did not differ substantially in both groups.

In proportion to the improvement in the general condition and the disappearance of symptoms of intoxication in the patients utilizing a free regimen, the majority of the indicators of the phase structure of the heart had normalized even a month after the beginning of complex treatment, and after 3 months, the contractile function of the myocardium was fully reestablished.

In the first group of patients, for the complex treatment of whom bed rest was necessary, chronometric symptoms of disturbance of the phases of cardiac activity and changes in the interphase and complex indicators occurred throughout the entire observation period. The disturbance of the struc-

ture of the cardiac cycle with prolonged hypokinesia has a phasic nature. The pronounced pathology of the contractile function of the myocardia is noted 1 month after the prescribing of bed rest, when a further shortening of the duration of the cardiac cycle ($P < 0.01$), an increase in the time of expulsion of an instantaneous volume of blood (19.96 ± 0.24 seconds, as opposed to 19.11 ± 0.21 seconds, $P < 0.05$), and a decrease in the power of the left ventricle (2.33 ± 0.26 watts, as opposed to 3.29 ± 0.29 watts, $P < 0.02$) are detected even as compared to the initial pathologic background. The remaining indicators of cardiodynamics corresponded to the initial data.

Subsequently, the phase shifts not only do not disappear, /11 but even continue to increase, which is clearly demonstrated in the third month of confinement to bed. In this period, we detected a shortening of the phase of isometric contraction, a lengthening of the electric systole, and a decrease in the initial rate of the increase in intraventricular pressure (122.9 ± 189.7 mm of mercury/sec., as opposed to 2315.2 ± 358.7 mm of mercury/sec., $P < 0.05$), which was not observed in the previous stages. In the sixth month of hypokinesia, a further shortening of the period of expulsion ($P < 0.02$) and the general systole of the heart ($P < 0.02$), and a reduction in the rate of emptying of the ventricles (204.30 ± 16.18 milliliters/sec., as opposed to 235.80 ± 37.70 milliliters/sec., $P < 0.02$). The index of myocardial tension increased even more ($30.63 \pm 1.41\%$, as opposed to $27.26 \pm 0.83\%$, $P < 0.05$). Such indicators as the mechanical systole, the diastole, and Blumberger's mechanical coefficient were substantially lower throughout the entire period of hypokinesia than in the healthy persons. Regularities were not noted in the variations of the duration of the electric systole, and, through analysis of the systolic indicator, we detected its

increase in all stages of observation. The intrasystolic indicator did not change reliably, as a result of the accompanying shortening of the period of expulsion and the mechanical systole.

The data obtained by V. L. Karpman through the analysis of the detected pathologic cardiodynamic syndromes indicate the phasic nature of the disturbance of the contractile function of the heart. In the initial period and in the course of the first three months of confinement to bed, the phase syndrome of hyperdynamia is encountered most often in the patients (in 56% of the cases in the initial period and in 53% after 3 months of hypokinesia, respectively), which indicates the tension of the contractile function of the myocardium. Subsequently, the frequency of the syndrome of hypodynamia increases (after 6 months—in 55% of the cases, after 9 months—in 73.3%, and after 1 year—in 70%), in proportion to the lengthening of the period of confinement to bed. It is characteristic that patients with a normal phase structure of the heart systole (in the initial period—5.8%, after 1 month—3.03%) are encountered in the first months of observation. Beginning with the third month of bed rest, not one patient with a normal polycardiogram was detected.

The patients are allowed out of bed upon inactivation of the tubercular process and elimination of complications of the basic disease (tuberculous abscesses, spinal disorders). Expanding of the regimen was preceded by therapeutic gymnastics, massage, and physiotherapy, directed chiefly at re-establishing the function of the damaged section of the locomotor system. Just like throughout the hypokinesia, the initial period, prior to expansion of the motor regimen, was characterized by a shortening of the duration of the cardiac cycle, the period of expulsion, the mechanical and

general systoles, and the diastole, and a lengthening of the phase of asynchronous contraction and the electric systole. Blumberger's mechanical coefficient was reduced (2.42 ± 0.23 , as opposed to 3.04 ± 0.20 , $P < 0.05$), and the index of tension of the myocardium was high ($29.46 \pm 0.92\%$, as opposed to $24.65 \pm 1.03\%$, $P < 0.05$). The power of the left ventricle and the rate of its emptying were lower than in the healthy persons (3.08 ± 0.46 watts, as opposed to 4.12 ± 0.14 watts, and 228.86 ± 17.33 milliliters/sec., as opposed to 358.64 ± 32.72 milliliters/sec., $P < 0.05$, respectively). The outlay of energy for expulsion of 1 liter of blood and the systolic indicator were increased (12.44 ± 0.77 , as opposed to 10.77 ± 0.38 watts/min., and $46.99 \pm 0.57\%$, as opposed to $41.12 \pm 0.74\%$, $P < 0.05$, respectively).

The reaction of the cardiodynamics to the increase in the motor activity during the first week after the patients left bed was expressed in the subsequent lengthening of the phase of asynchronous contraction ($P < 0.01$), and the general and electric systoles of the heart ($P < 0.01$). Subsequently, some indicators return to the initial level; however, even 3-4 months after the patients have left bed, considerable phase shifts are noted, which indicate the deficiency of the contractile myocardium in them.

/12

Thus, the obtained data indicate that the disturbance of the contractile function of the myocardium in patients with surgical tuberculosis is aggravated, to a considerable degree, by prolonged deficiency of muscular activity, associated with confinement to bed. It should be emphasized that the pronouncedness of the cardiodynamic disturbances in this case is in direct dependence on the duration of the hypokinesia. It is possible that some phase shifts are a compensatory act for the change in the conditions of circu-

lation, associated with hypodynamia and the horizontal position of the body. However, the shortening of the cardiac cycle throughout the period of confinement to bed indicates the stress on the functional capabilities of the heart, while the lengthening of the phase of asynchronous contraction and the reduction in the power of the left ventricle with a high energy outlay, according to the data of some authors (S.B. Fel'dman, 1965; V.P. Nikitin, 1967), are the causes of cardiac decompensation.

All of this requires the use of definite measures for the prophylaxis and treatment of cardiac insufficiency with prolonged hypokinesia in patients with surgical tuberculosis.